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OFFICE OF SUBSISTENCE MANAGEMENT
FISHERIES RESOURCE MONITORING PROGRAM

KLAG BAY SOCKEYE SALMON STOCK ASSESSMENT, 2002

by

Jack Lorrigan
Margaret Cartwright
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REGIONAL INFORMATION REPORT[1] NO. 1J04-18

Annual report to the
U.S. Forest Service to
fulfill obligations for
study number FIS 01-128-1

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[1] The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Division of Commercial Fisheries.

ANNUAL REPORT SUMMARY PAGE

Title: Klag Bay Sockeye Salmon Stock Assessment Study Number: FISO1-128-1

Investigators/Affiliations: Jack Lorrigan Sitka Tribe of Alaska; Margaret Cartwright and Jan Conitz/Alaska Department of Fish and Game, Division of Commercial Fisheries; Terry Suminski/U.S. Forest Service, Sitka Ranger District; Benjamin Van Alen/ U.S. Forest Service, Juneau Ranger District.

Management Regions: Tongass National Forest, West Chichagof/Yakobi Wilderness Area.
Information Type: Stock Status and Trends

Issues Addressed: Sockeye population viability and potential loss of subsistence opportunity. Assure that escapement levels are adequate to provide sustainable subsistence harvests. Klag Bay is the third most important producer of sockeye salmon for subsistence users in Sitka. Sitka is the largest rural community in Southeast Alaska that has Customary and Traditional use Determination. Reliable estimates of the escapement and subsistence harvest are needed.

Study Cost: $572,025 (3 years)

Reporting Period: 2002 Season

Key Words: Chichagof Island, escapement, hydroacoustics, Klag Lake, limnology, mark-recapture, *Oncorhynchus nerka,* radio tagging, sockeye salmon, subsistence, weir, Tribal co-management, customary and traditional use.

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SPONSORSHIP

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ABSTRACT

The return of adult sockeye salmon to Klag Lake in 2002 was estimated through a survey of subsistence and sport harvest in the terminal area at Klag Bay, weir counts, and verified with a mark-recapture study. Age, length, and sex composition of the escapement was estimated using standard measurements and scale sampling and analysis. Sockeye salmon fry populations in each lake were estimated using hydroacoustic and trawl sampling. Baseline information was collected on the physical characteristics and productivity of lake rearing habitat in each system using standard limnological sampling procedures. A healthy return of adult sockeye salmon was documented, with a total harvest estimate of about 3,159 fish, comprising 15.2% of the total return, and an escapement estimate of about 17,684 fish. The mark-recapture estimate validated the weir count and indicated that few sockeye salmon passed through the weir uncounted. According to results of age and length analysis, about 2% of the adult sockeye salmon sampled at the weir were jacks. The dominant age class was age-1.3, representing 44% of the fish sampled. The next largest class was age-1.2, representing 28% of the fish sampled. Sockeye salmon fry density was only moderate, compared to that in similar Southeast Alaska sockeye salmon rearing lakes. Klag Lake has a large population of sticklebacks as noted in 2001; according to trawl sample results this year, they comprised about 30% the fish detected during the hydroacoustic survey, sockeye fry however comprised 67% of the trawl sample. Klag Lake has a shallow euphotic zone, averaging 4.5 m in 2001 and 5.8m in 2002, and a thermocline in 2002 between 5 – 15m. Good baseline information was obtained in 2001 and 2002, but since little previous data exists on the Klag Lake sockeye salmon population, and the wide range of returns it is too early to draw conclusions regarding optimum harvest and escapement sizes. More years of data will be needed to show trends in population and lake productivity over time.

INTRODUCTION

Sitka is the largest rural community with customary and traditional use determinations in Southeast Alaska for many species, including sockeye salmon (Figure 1). Klag Lake (ADF&G Stream No. 113-72-002) is one of the largest producers of sockeye salmon in Southeast Alaska. The Klag Bay area was historically used by the clans living in the Sitka area and continues to be an important resource for the people of Sitka (Conitz and Cartwright 2002). Historical accounts mention some commercial fishing in the area. However, current management of the commercial pink and chum fisheries exclude Klag Bay (Conitz and Cartwright, 2002). Very little stock assessment work was done prior to the beginning of this research project in 2001 (Conitz and Cartwright, 2002).

This annual report summarizes the sockeye salmon stock assessment data collected in the second year of the project. The primary focus of the study is to collect harvest and escapement data on adult sockeye salmon returning to the terminal area (Klag Bay) and to the lake respectively. The study also includes an assessment of the lake's physical characteristics, which support primary (algae) and the secondary production (zooplankton). Zooplankton is the main food source for sockeye salmon, and cladocerans are their preferred food within the zooplankton community. By estimating the biomass and number of zooplankton by species, we can evaluate whether food is a limiting factor for juvenile sockeye salmon in Klag Lake. The species composition over the season and between years may provide insight into how the zooplankton community responds to different fry densities and adult escapement levels. Juvenile sockeye salmon population characteristics, including density, size, and age composition, are indicators of sockeye salmon response to conditions within the lake and are estimated using hydroacoustic methods. Returning adults are sampled for size, sex and age (scales) to reconstruct the population by brood year.

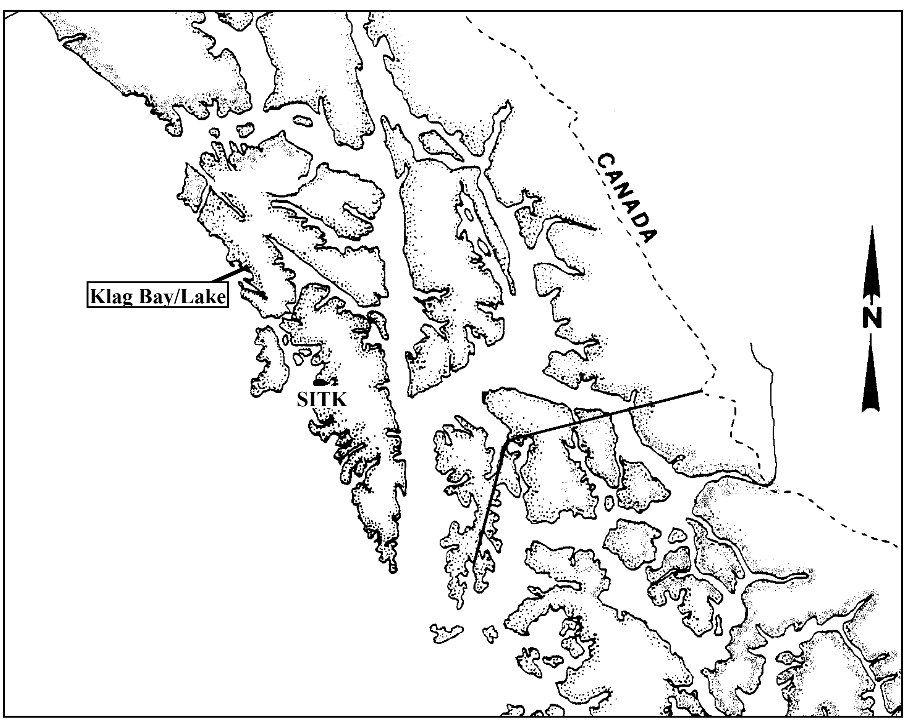

Figure 1. The location of Klag Bay on Chichagof Island and Sitka.

OBJECTIVES

(1) Estimate the escapement of sockeye salmon and other salmonids into the Klag Lake system, with the aid of a weir on the outlet stream of the lake and additional mark-recapture censuses, so that the estimated coefficient of variation is less than 10%.

(2) Estimate the subsistence harvest of sockeye salmon from Klag Bay, so that the estimated coefficient of variation is less than 15%.

(3) Describe the age and length distribution of sockeye salmon spawners in the Klag Lake.

(4) Estimate a conversion between in-lake survey/mark-recapture estimates and the total estimated escapement of sockeye salmon such that the estimates have a coefficient of variation less than 20%.

(5) Estimate the in-lake productivity of Klag Lake using established ADF&G limnological sampling procedures. Secondary objectives, depending on availability of funding and characteristics of system:

(6) Estimate the sockeye fry rearing density within Klag Lake, using hydroacoustic methods, so that the estimated coefficient of variation is less than 10%.

(7) Estimate the age, sex and size composition of sockeye smolt such that these estimates are within 10%, 90% of the time.

METHODS

Study Site

Klag Bay (N 57°38.5’, W 136°42.2’) is the outermost bay in a system of enclosed saltwater bays or lakes, which includes Lake Anna and Sister Lake. The Klag Lake drainage is approximately 7 km^2, with a maximum elevation of about *550* m, and consists of sparsely wooded low hills with large areas of muskeg and numerous small, shallow lakes and ponds. A chain of small lakes and ponds to the northeast forms the only permanent inlet stream to Klag Lake. A 1.3 m falls in this stream forming a partial migration barrier to salmon, especially at low to moderate flows. Klag Lake lies at an elevation of about 12 m, and is about 43 m deep with a surface area of about 83 hectares (Figure 2). The outlet stream flows through a series of three large ponds into the east side of Klag Bay. The extensive network of muskegs and small ponds in the Klag Lake drainage tends to buffer the system against extreme changes in depth and flow volume. In addition to sockeye salmon *(Oncorhynchus nerka),* Klag Lake supports small runs of pink*, (0. gorbushca)* and coho *(0. kisutch)* salmon, and resident populations of cutthroat trout *(Oncorhynchus clarki* spp.) and three spine stickleback *(Gasterosteus aculeatus).* Chum salmon *(0. keta),* Dolly Varden *(Salvelinus malma)* and steelhead *(0. mykiss)* have also been observed in the Klag Lake outlet.

Figure 2. Bathymetric map of Klag Lake, showing 5 m depth contours and two permanent limnology sampling stations (A and B).

Juvenile Sockeye Population Assessment

Hydroacoustic and mid-water trawl surveys were used to estimate the distribution and abundance of sockeye salmon fry in Klag Lake. Prior to conducting the survey, Klag Lake was divided into 4 sections based on lake area and shape. Ten evenly spaced orthogonal transects were identified within each section and two of these were randomly selected to be surveyed. Transects selected in 2002 became permanent and will be repeated during future surveys. The decision to keep the transects fixed each year reflects a decision to emphasize measurements in year-to-year change in population size.

During the acquisition of acoustic targets, we surveyed each selected transect from shore to shore, beginning and ending the sampling at a depth of 10 m. Sampling was conducted during the darkest part of the night. A constant boat speed of about 2.0 m $\cdot$ sec^{-1} was attempted for all transects. The acoustic equipment consisted of a Biosonics[2] DT-4000™ scientific echo sounder[1] (420 kHz, 6° single beam transducer) with and Biosonics Visual Acquisition © version 4.0.2

[1] Product names used in this publication are included for scientific completeness but do not constitute product endorsement.

software was used to collect and record the data. Ping rate was set at 5 pings · sec^{-1} and pulse width at 0.4 ms. Only target strengths ranging from –40 dB to –68 dB were recorded because this range represents fish within the size range of juvenile sockeye salmon and other small pelagic fish.

Midwater trawl sampling was conducted in conjunction with the hydroacoustic surveys to determine the species and age (sockeye fry only) composition of the targets. A 2 m x 2 m elongated beam-trawl net with a cod-end was used for the trawl sampling. An exploratory surface tow was conducted to determine if there are fish on the surface not detected by the down-looking hydroacoustic gear. In clear and stained lakes, the surface tow will not be repeated unless we catch fish. Because juvenile sockeye can be present at shallow depths in glacial lakes surface tows will be conducted on glacial lakes every year (Burgner 1991). The surface tow was conducted by attaching floats to the top of the tow net so that it floated just beneath the lake surface 30 m back from the boat. Next, trawl sampling was conducted in the area of the lake with the highest concentration of fish, identified during the hydroacoustic survey. These tows were conducted at two depths within this high target density area. Two replicate tows are conducted at each depth. The second tow, at a given depth, was started at the termination point of the first tow. The direction of the second tow for each depth was selected such that it does not sample the same area as the first tow. The trawl duration ranged from 15 to 30 minutes, depending on fish density. If warranted, a second complete set of tows was conducted in a morphologically distinct section of the lake or in a second area of high target densities.

All adult fish caught in the midwater trawl were identified, counted, and released. All small fish from the trawl net were euthanized with MS 222. Fish were preserved with 90% alcohol. Samples from each tow were preserved in separate bottles. The bottle was labeled with the date, lake name, tow number, tow depth, time of tow, and initials of collectors. Fish captured in the tow samples were analyzed at the laboratory to determine species composition and age distribution of sockeye juveniles. The species composition of the midwater trawl samples was pooled and applied to the total target estimate to calculate each species-specific population estimate and variance. The sockeye fry density and age composition was also calculated using the sockeye fry trawl sample data.

In the laboratory, fish were soaked in water for 60 minutes before sampling to re-hydrate the samples. All fish were identified and the snout-fork length (to the nearest millimeter) and weight (to the nearest 0.1 gram) were measured on each fish. All sockeye salmon fry under 50 mm were assumed to be age-0. Scales were collected from sockeye fry over 50 mm and mounted onto a microscope slide for age determination. Sockeye fry scales were examined through a Carton microscope with a video monitor and aged using methods outlined in Mosher (1968). Two trained technicians independently aged each sample. The results of each independent scale ageing were compared. In instances of discrepancy between the two age determinations, a third independent examination was conducted. A proportion of each age class of sockeye fry is used to allocate the hydroacoustic sockeye fry estimates by age. Data were recorded onto a form and then entered into an MS Excel spreadsheet.

DATA ANALYSIS

Data were analyzed using Biosonics Visual Analyzer © version 4.0.2 software. Echo integration was used to generate a fish density (targets · m^{-2}) for each of the sample sections (MacLennand and Simmonds 1992). Mean target density for each section was calculated as the average of the two replicate transects. The mean target density for the whole lake was calculated as a weighted average of target density per section, with the area of each section as the weights. A target estimate for each of the sample sections was calculated as the product of the mean target density and the surface area of each of the sample sections. Summing the section estimates generated a total target estimate for the whole lake. The variance of this total target estimate was calculated based on 1 degree of freedom estimates for each pair of transects in each section. Because each section was sampled independently from other sections, the estimated sampling variance for the whole lake estimate was calculated as the sum of the target estimate variances for each section (V_T). Sampling error and the coefficient of variation (CV) for the estimate of total targets for the whole lake was calculated and the coefficient of variation (Sokal and Rohlf 1987). A CV greater than 10% will necessitate adding additional sample sections to Klag Lake the next year.

The apportionment of targets into species composition categories allowed us to get a rough estimate of sockeye fry abundance in those lakes where we had adequate trawl data. An obvious way to estimate the sockeye fry abundance in the entire lake is to simply pool all fish caught in all trawl samples (except the surface tow) into one sample, calculate the proportion of sockeye fry in the pooled sample, and then use this proportion to adjust the estimate of total sonar targets in the lake to an estimate of total sockeye fry. Although this approach should give a reasonable and very usable estimate of the number of sockeye juveniles present in the lake, unfortunately, this approach leaves us without a means to estimate the sampling error in the estimate.

We first assumed that sockeye fry are completely randomly distributed within the lake, and therefore within the multiple trawl samples. If so, we reasoned that the estimate of sampling error could be based on an approximation to the binomial distribution, which is well studied, and formulas for confidence intervals or standard errors can be found in any elementary statistical textbook. We began by developing rules for sample size requirements and using chi-squared tests for heterogeneity to test for similarity among trawl samples. We reasoned that if we had greater than 30 fish targets per trawl sample, if the assumptions of the chi-squared test were met (greater than 5 expected counts per cell and a fairly uniform distribution), that the small observed chi-squared statistics would mean that the binomial approximation would be a usable assumption. However, we found that we had inadequate sample sizes to compare trawls at the same depth with these chi-squared tests. When we pooled the samples into one or more depth categories, in general, we got small chi-squared statistics with small sample sizes and lager chi-squared statistics with larger sample sizes. In the end, we concluded that a simple, defendable estimate of the variance associated with the estimate of the proportion of sockeye fry is not possible because of the non-uniform distribution of sockeye fry in the lake, the clustering of sockeye fry within the samples and the small sample sizes. If we assume that the distribution is clumped, a negative binomial distribution to account for the clusters could be used if we had adequate trawl samples at each depth. Computation of adequate sample sizes is complex and not completed to date. It is clear that increased sampling is needed to obtain accurate estimates of fry density in the future.

Adult Escapement Estimates

Weir Count and Weir Mark Recapture Estimate

A weir was installed in the outlet stream of Klag Lake to count all salmonids entering the lake. The accuracy of the weir count of sockeye salmon was verified with a mark-recapture estimate of escapement, using the weir as a marking platform. Biological sampling was also conducted at the weir, including species identification, and sockeye salmon mid-eye to fork length measurements, and scale collection for aging.

A wooden tripod, picket and channel type weir was constructed across the Klag Lake outlet stream about 100 meters upstream from the estuary. Seven tripods and 8 picket panels, each holding 53 pickets, were installed just above the mean high tide level. Tides higher than 10.6 ft rose above the base level of the weir; such tides occurred about 25% of the time during the operation of the weir. The weir was reinforced against high water and possible washout using sandbags, and was held in place by means of cables tied to trees upstream. Migrating fish were funneled into a 4 ft x 4 ft x 8 ft box frame trap, from which they were counted, marked, measured and scale sampled before they were released upstream. The weir operated continuously from June 18 to September 11. The first sockeye adults passed through the weir on July 4.

A stratified two-sample mark-recapture study was conducted to test the integrity of the weir and provide an alternative estimate of sockeye salmon escapement into Klag Lake. Marks given sockeye salmon at the weir were stratified by time, to allow separate estimation of different parts of the run, should the weir fail or violations of mark-recapture assumptions occur during some part of the run (Arnason et al. 1995). A constant 50% daily marking rate was specified in the operating procedures, but the number of fish passing the weir, especially on peak days, was larger than expected; an overall cumulative marking fraction of 18% was obtained by the end of the run. We clipped the adipose fin on all marked fish and used this as a universal mark, signaling the observer to look for a seasonal mark. A second mark was used as the seasonal mark. The marking strata were from July 4-26 (left axillary), July 27 – August 14 (left pelvic), and August 5 – September 11 (dorsal). Recapture events were conducted on the spawning grounds on September 2, 3, 4, 6, and 12. The recapture study area was the inlet stream above Klag Lake to a partial barrier falls. Both live and dead fish were examined for marks in a portion of the spawning areas; all sampled fish were marked with a secondary mark to prevent duplicate sampling.

DATA ANALYSIS

To test assumptions, we decide to pool or stratify the data and to calculate a mark-recapture estimate, using the Stratified Population Analysis System (SPAS) software program (Arnason et al. 1995). The SPAS program is designed to evaluate 2-sample mark-recapture data where marks and recoveries take place over a number of strata.

The SPAS program calculates the 1) maximum likelihood (ML) Darroch estimates and pooled-Petersen (Chapman's modified) estimates. The ML Darroch model takes full advantage of stratification in the data and estimates abundance and its precision for each of the strata. SPAS produces goodness of fit test for this model. If the test gives a p-value bigger than 0.05, we think the model passes the test and the estimates of abundances and their precisions are valid. Because we want to estimate the escapement only, the advantage of SPAS is that it allows us to pool together some or even all of capture or recapture strata so that we can have a more precise estimate of escapement without introducing a serious bias. If a simple Petersen estimate is applied to the stratified data that have been pooled, it is called the pooled Petersen estimate (Seber 1982).

However, the pooled Petersen estimate can be badly biased when the assumption of equal catchability is violated. SPAS uses chi-square tests to test for complete mixing and equal proportions. If either test passes (i.e., $p > 0.05$), we think it is safe to use the pooled Petersen estimate. Even if the tests indicate rejection of pooling, this does not mean that partial or complete pooling is invalid. Other criteria should be examined, including seeing if pooling produces big changes in the estimate of escapement. If pooling leads a small change, it appears safe for pooling, otherwise, if pooling leads a big change in the estimate, it may be badly biased. In the exercise of pooling using SPAS, we expected to pool as many strata as possible to increase precision as long as the assumptions about mixing and equal proportions are not both violated. In case that both ML Darroch model and pooling approach fail, the estimates of abundances cannot be made.

If we can pool the data, a 95% confidence interval for the pooled Petersen estimate was constructed by pooling the data from all marking and all recapture strata and treating the pooled data as a single estimate. We used Chapman's modification of the Petersen Method (Seber 1982) to estimate abundance of sockeye escapement as:

$$\hat{N} = \frac{(\hat{M}+1)(C+1)}{(R+1)} - 1 \qquad (1)$$

where: $\hat{N}$ = estimated abundance of sockeye salmon escapement,
$\hat{M}$ = number of marked sockeye salmon;
C = number of adults inspected for marks; and
R = number of adults with marks in samples.

The conditions for accurate use of this methodology are that all sockeye within a strata:

1. have an equal probability of being marked at Klawock Lake; or
2. have an equal probability of being inspected for marks; or
3. marked fish mixed completely with unmarked fish in the population between events; and
4. it is a closed population; and
5. there is no mark-induced mortality; and

6. fish do not lose their marks and
7. all marks are recognizable.

The standard error of that estimate will be calculated as:

$$\mathrm{SE} = \sqrt{v\left(\hat{N}\right)} \qquad (2)$$

where $v(N)$ is

$$v\left(\hat{N}\right) = \frac{(m+1)(c+1)(m-r)(c-r)}{(r+1)^2(r+2)} \approx \frac{\hat{N}(m-r)(c-r)}{(r+1)(r+2)} \qquad (3)$$

Spawning Grounds Mark-Recapture and Visual Survey

Mark-recapture studies on the spawning grounds provided an independent estimate of sockeye escapement at Klag Lake. The spawning grounds estimate would be compared with the weir estimate, so that this less expensive method could be reliably used in years when the weir was not operated. We conducted four to five two-day mark-recapture events in the inlet stream spawning area, accompanied by visual surveys of the lakeshore and inlet streams.

The study design consisted of two sampling stages: 1) a two-sample Petersen estimate for each trip (Seber, 1982) and 2) a multiple trip estimate using a modified form of the Jolly-Seber method for multiple mark-recaptures in an open population (Seber, 1982; Cook, 1998). In the first stage, fish were marked on one day and examined for marks the next day; a simple Petersen population estimate was generated from these data (Seber, 1982).

Sockeye salmon were sampled with beach seine and dipnets in the inlet stream. All sockeye salmon caught on the first day were marked with a left opercular punch, and released with a minimum of stress. On the second day, all sockeye salmon in the samples were inspected for the left opercular punch, and given a secondary, right opercular punch to prevent re-counting. The total sample size, the number of new fish marked, and the number of recaptured fish with marks were recorded. A simple Petersen estimate of the number of fish present in the inlet stream on September 12 was generated using the same method for the pooled Petersen estimate in the "Weir and Weir Mark-Recapture" methods description above.

The crew only completed one mark-recapture event between September 11-12, providing a one-time "instantaneous" population estimate, but no complete estimate of escapement. Prior to the mark-recapture event, on September 11, the crew made a visual count of sockeye spawners in around the lakeshore and in the main inlet stream where spawners were present.

Escapement Age and Length Distribution

Scales, matched with sex and length data, were collected from adult sockeye salmon at the Klag Bay weir. The sampling goal was 600 fish. Three scales were taken from the preferred area of each fish (INPFC 1963), and prepared for analysis as described by Clutter and Whitesel (1956). Scale samples were analyzed at the ADF&G salmon aging laboratory in Douglas, Alaska. Age and length data were paired for each fish sample. Age classes were designated by the European aging system where freshwater and saltwater years are separated by a period (e.g., 1.3 denotes 1-year freshwater and 3-years saltwater; Koo 1962). Brood year tables were compiled by sex and brood year to describe the age structure of the returning adult sockeye salmon population. The length of each fish was measured from mid-eye to tail fork to the nearest millimeter (mm).

Let n be the total number of samples aged, n_k be the number of samples in age-sex group k, and N be the estimated escapement. The proportion of each age-sex group k was calculated by

$$\hat{p}_k = \frac{n_k}{n}. \qquad (4)$$

The estimated standard error was derived from the binomial formula (Thompson 1992, p. 35-36):

$$SE(\hat{p}_k) = \sqrt{\frac{\hat{p}_k(1-\hat{p}_k)}{n-1}}. \qquad (5)$$

The estimated mean length and associated standard error for age-sex group k were calculated as the sample mean of a simple random sample:

$$\bar{y}_k = \frac{1}{n_k}\sum_{i=1}^{n_k} y_{ki}\ , \text{ and } \ SE(\bar{y}_k) = \sqrt{\frac{1}{n_k}}\sqrt{\left(\frac{1}{n_k-1}\right)\sum_{i=1}^{n_k}(y_{k\,i}-\bar{y}_i)^2} \qquad (6)$$

(Thompson 1992, p. 42-43).

Subsistence Harvest Estimation

The Klag Lake subsistence fishery for sockeye salmon is open from June 1 through July 25, unless closed by ADF&G emergency order. The study design for the Klag Bay marine subsistence fishery was originally based on a stratified two stage sampling design (Bernard et al. 1998, Cochran 1977). Given that all days were sampled, the two-stage sampling design was collapsed to a single-stage sampling design. The sampling day was all daylight hours; the crew was up and able to monitor the fishery, seven days a week. We assumed that all fishers could be interviewed and missed interviews were random events that could be incorporated in the final estimate by expanding the numbers reported in the interviews to account for the missed ones. However, some boat parties chose to leave the area without completing an interview or refused to give information when approached by a crewmember. This happened several times, despite the crew contacting them at least once to initiate an interview. These instances were recorded as missed interviews; if the sampler was able to estimate a catch from observation or third person reporting, that was noted in the comments.

The primary sampling unit was boat-parties per day. This design was appropriate because participating boats could be accurately counted and most could be interviewed after they completed fishing for the day. The design was stratified by angler type. Sport fishers (using hook and line) were one stratum, subsistence fishers using gillnets were a second stratum, and subsistence fishers using seines were a third stratum.

As a fishing boat entered the area, the sampler contacted the group by radio or by motoring out, gave a short explanation of the creel survey, determined the group’s sport or subsistence gear use, and requested that the boat party contact the samplers as they prepared to leave the area so the interview could be completed. Data collected during each interview included angler effort (rod or net hours), gear type used, and harvest by species. If the technician was unable to interview a party because two or more boats were leaving at the same time, one boat was randomly selected using a coin toss. Samplers maintained a view of the fishing area during the entire sampling period. Boat parties that left the fishery without being interviewed were counted according to their previously identified sport or subsistence gear use, along with additional information.

Data Analysis

At Klag Lake, fishers use several different gear types to harvest salmon; each gear type harvested more than one species of salmon. Therefore, estimates of harvests and variances for each species within each fishery type was calculated in a separate category. Summing harvest and variance estimates across all fishery types yielded the estimated total harvest and associated variance for each species caught.

For estimates of harvest, let $h_{g,j}$ equal the number of fish harvested by boat-party j that is classified as belonging to a gear category g. Let M_g equal total number of boat-parties in category g that participated in the fishery, and let m_g equal number of boat parties in category g interviewed over the course of the fishery. The estimate of total harvest is then calculated as,

$$\hat{H}_g = \frac{M_g}{m_g} \sum_{j=1}^{m_g} h_{g,j} \tag{7}$$

The variance of the harvest will be estimated as,

$$\operatorname{var}(\hat{H}_g) = M_g^2 (1 - \frac{m_g}{M_g}) \frac{\sum_{j=1}^{m_g} (h_{g,j} - \bar{h}_g)}{m_g (m_g - 1)}, \tag{8}$$

where $\bar{h}_g$ denotes the mean harvest per boat-party, for the g^{th} category over the entire season. The estimated total harvest and associated sampling variance for each species caught will be determined by summing estimates over all fishery types. Effort for the sport fishery categories can be estimated by substituting E and e for H and h in the two immediately preceding equations.

Limnology Sampling

Limnology sampling was conducted at two stations on Klag Lake on May 31, July 17, August 29 and October 30 to measure euphotic zone depth, temperature, light and dissolved oxygen, and to collect zooplankton samples. Physical measurements were made at Station A only, the deeper of the two and one zooplankton sample was collected at Stations A and B.

Light, Temperature, and Dissolved Oxygen Profiles

Underwater light intensity was recorded from just below the surface to the depth where measured intensity was one percent of the surface light reading, at 0.5 m intervals, using an electronic light sensor and Protomatic meter for the first 2 trips and a YSI 85 light meter for the second 2 trips. The vertical light extinction coefficients (K_d) were calculated as the slope of the light intensity (natural log of percent subsurface light) versus depth. The euphotic zone depth (EZD) was defined as the depth to which one percent of the subsurface light [photosynthetically available radiation (400-700nm)] penetrates the lake surface (Schindler 1971), and is calculated from the equation: EZD = 4.6205/ K_d (Kirk 1994). The euphotic zone depth defines the part of the lake where photosynthesis is possible.

Temperature and dissolved oxygen (DO) profiles were measured with a Yellow Springs Instruments (YSI) Model 58 DO meter and probe, in absolute (mg L^{-1}) values for DO and in ºC for temperature. Measurements were made at 1 m intervals to the first 10 m or the lower boundary of the thermocline (defined as the depth at which the change in temperature decreased to less than 1ºC per meter), and thereafter at 5 m intervals to within 2 m of the bottom (or 50 m). The dissolved oxygen meter reading at 1 m was calibrated at the beginning of a sampling trip using the value from a 60 ml Winkler field titration (Koenings et al. 1987).

Secondary Production

Zooplankton is the primary food for sockeye salmon and cladocerans are their preferred food within the zooplankton community. By estimating the biomass and number of zooplankton by genera and in some cases by species throughout the season, we can observe how the species composition changes over the season and between years. This information may provide insight into how the zooplankton community responds to different fry densities and adult escapement levels. Zooplankton samples were collected at two stations using a 0.5 m diameter, 153 um mesh, 1:3 conical net. Vertical zooplankton tows were pulled from a maximum depth of 50 m, or 2 m from the bottom of the lake if shallower than 50 m, at a constant speed of 0.5 m sec^{-1}. The net was rinsed prior to removing the organisms, and all specimens were preserved in neutralized 10% formalin (Koenings et al. 1987). Zooplankton samples were analyzed at the ADF&G Commercial Fisheries Limnology Laboratory in Soldotna, Alaska. Identification to genus or species, enumeration, and density and biomass estimates were performed as in 2001 (Conitz et al. 2002; Koenings et al. 1987). Zooplankton density (individuals per m^2 surface area) and biomass (weight per m^2 surface area) were estimated by species and by the sum of all species (referred to as total zooplankton density or biomass). The mean size of each zooplankter species was also estimated from a subsample of specimens. The size of the cladocerans is especially important because the sockeye fry tend to shift to less preferred zooplankton if the cladocerans are less than 0.5 mm (Asit Mazumder, personal communication). Smaller cladocerans sizes may also indicate the predation pressure is high (i.e., the sockeye fry production may be limited by food; Brooks and Dodson 1965).

RESULTS

Juvenile Sockeye Population

A hydroacoustic survey and a mid-water trawl sampling were conducted on August 25, 2002. A total of 136 sockeye salmon fry, 66 sticklebacks, and 1 coho fry were caught in the five mid-water trawl sets performed with the hydroacoustic survey. The trawl effort consisted of 5 tows, a single 15-minute tow at the surface (1 m), two 15-minute tows at 7 m, and two 15-minute tows at 9 m (Table 1). Sticklebacks were the only fish caught in the surface tow and approximately 30% of the total number of sticklebacks was caught at the surface (n=22; Table 1). Most of the sockeye fry and sticklebacks were caught in the first tow at a given depth, the area identified as having a high concentration of targets (Tow 2 and 4). The replicate tows (tow 3 and 5) had a very different sockeye fry age compositions compared to the first tow at each depth (Table 1). Sockeye fry dominated the trawl catch in 2002 (67%) compared to only 22% sockeye fry composition in the 2001 trawl sample. The proportion of sockeye fry caught in 2002 is even higher (75%) if we exclude the surface tow, which was not performed in 2001. The depths of the tows in 2001 were slightly shallower (5 and 8 m).

The biological characteristics of the trawl sample was described by age (sockeye only), length and wet weight. Eighty-six percent of the sockeye were age-0 (n=117) and 14% were age-1 (n=19; Table 2). The mean snout-fork length of the age-0 sockeye salmon fry was 50 mm (SE = 0.4 mm) and a mean weight of 1.1 g (SE = 0.03 g; Figure 3). The mean snout-fork length of the age-1 sockeye salmon fry was 78 mm and a mean weight of 4.1 g. A SE was not calculated for the age-1 sockeye fry due to the non-normal distribution of the small sample. The snout-fork length of sticklebacks ranged from 30 mm to 68 mm and most likely included several age classes. The coho fry was an age-1 fry.

We estimated a total number of targets represented 189,200 pelagic fish in Klag Lake in 2002. The target CV (not to be confused with the sockeye fry CV) was 7%, indicating the number of sections in the survey was adequate. By apportioning the trawl data by species, we estimated about 126,800 sockeye fry, 61,500 sticklebacks, and 900 coho fry were present in the lake (Table 2). As stated in the methods, we were unable to estimate the variation around these population estimates due to the inadequate numbers of trawls and low sample sizes within the trawls performed.

Table 1. The distribution of small pelagic fry caught in the tow net by species, age and depth.

Tow #	Depth (m)	Time (min)	Sockeye Age-0	Sockeye Age-1	Sockeye Total	Percent Sockeye	Percent Age-0 Sockeye	Stickleback All ages	Coho Age-1
1	surface	15				0%	0%	22	
2	7	15	30	1	31	69%	97%	14	
3	7	15	2	4	6	75%	33%	2	
4	9	15	82	8	90	76%	91%	25	1
5	9	15	3	6	9	75%	50%	3	
Grand Total			117	19	136	67%		66	1

Table 2. Size and age distribution of sockeye fry and stickleback estimated from midwater trawl samples, and population estimates based on hydroacoustic surveys with species and age apportionment based on trawl samples, for Klag Lake, 2002.

Species	Age	Sample Size	Proportion of Total	Mean Length (mm) (±SE)	Mean Weight (g) (± SE)	Population Estimate by Age
sockeye fry	0	117	0.58	50 (0.4)	1.1 (0.03)	109,100
sockeye fry	1	19	0.09	78	4.1	17,700
stickleback	na	66	0.33	52	1.3	61,500
coho fry	1	1	0.005	81	4.9	900

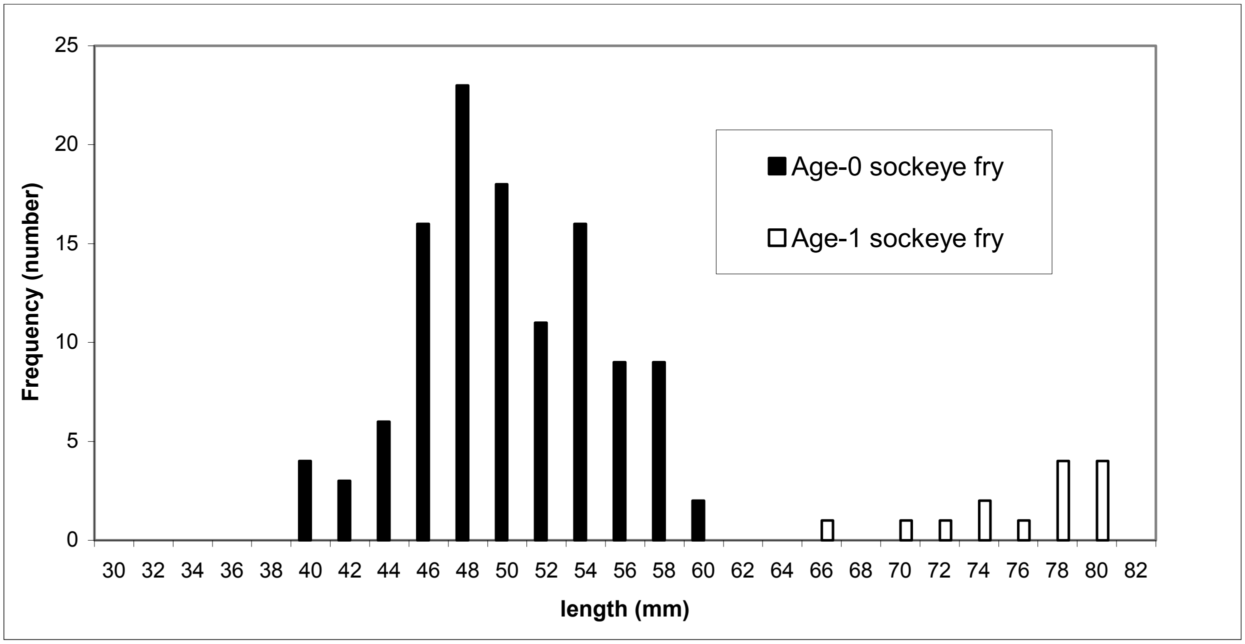

Figure 3. Length frequency distribution of sockeye salmon fry in Klag Lake, 2002. All sockeye fry less than 50 mm long were assumed to be age-0. Sockeye fry greater than 50 mm long are aged according to scale pattern.

Adult Escapement Estimates

Weir Count and Weir Mark Recapture Estimate

The first sockeye salmon showed up at the weir on July 4, two weeks after the weir was installed. A total of 17,684 sockeye salmon were counted through the Klag Lake weir (Table 3). Peak escapement days were July 25, July 26, August 7, 8, 9, 10 and August 21, with 598, 751, 2,192, 4,577, 1,699, 1,941 and 2,413 sockeye salmon, respectively, entering the Klag Lake outlet stream (Figure 4). With the exception of the first high water event, the sockeye adults returning to Klag Bay appeared to move through the weir to the lake a few days prior to high water (Figure 4). Peak daily escapement for all species appeared to be associated with increasing or peak water levels in the creek.

Table 3. Weir counts and a mark-recapture escapement estimate for Klag Lake sockeye salmon and other salmonids during 2002.

Species	Weir Count	Petersen Mark-Recapture Estimate	95% Confidence Interval for Petersen Est.
Sockeye	17,684	17,307	(15,694 - 19,411)
Coho	3,767		
Pink	27,462		
Chum	24		

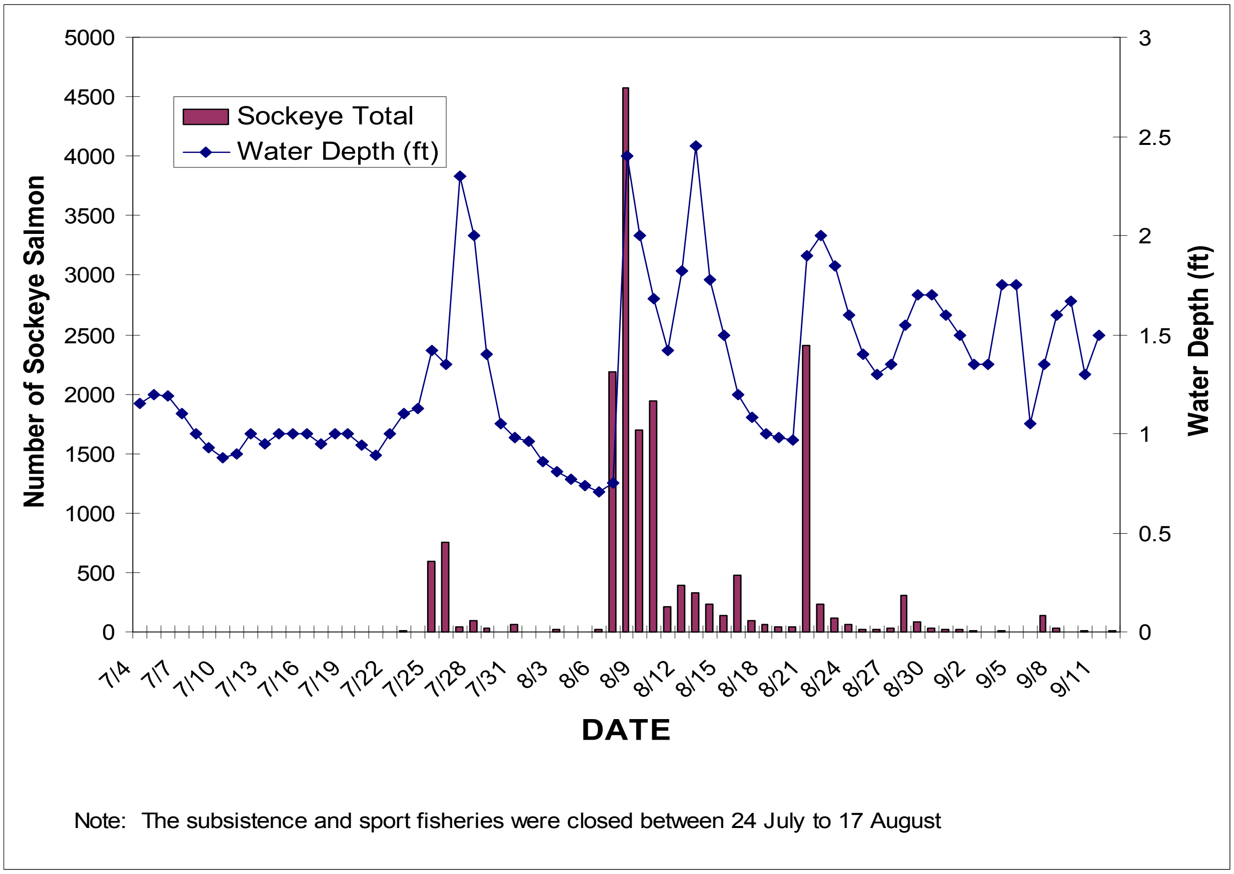

Figure 4. The Klag Lake daily count of sockeye salmon at the weir (solid bar) and the daily water level at the weir (line) in 2002.

In the mark-recapture study, we marked 3,173 sockeye salmon at the weir, averaging about 18% of the run (Table 4). Although a disproportionate number of fish were marked with the last mark (AD+LP), the percent marked by each mark type ranged from 17% to 24% between the three seasons (Table 4).

Table 4. The number of sockeye salmon marked and the weir count by mark type, 2002.

	AD+D	AD+LA	AD+LP	Total
Number marked	831	325	2,017	3,173
Weir count	4,436	1,378	11,870	17,684
Percent marked	19%	24%	17%	18%

Of the 1,455 sockeye salmon recaptured on the spawning grounds between September 2 and 12, a total of 266 marked fish were recaptured. The range of the proportion of marks recovered was fairly small, 15-20% (Table 5).

Table 5. 2002 Summary of the marked and unmarked sockeye salmon recaptured on the spawning ground in Klag Lake.

Date	Location	Unmarked	Recaptured Fish Ad+D	Ad+LA	Ad+LP	Total Marked fish	Total Caught	Percent Marked of Total
9/2/02	inlet stream	106	3	8	8	19	125	15%
9/3/02	inlet stream	161	8	13	18	39	200	20%
9/4/02	inlet stream	208	7	13	25	45	253	18%
9/4/02	inlet stream	285	12	28	26	66	351	19%
9/6/02	inlet stream	100	8	4	11	23	123	19%
9/12/02	inlet stream	329	26	13	35	74	403	18%
Total		**1189**	**64**	**79**	**123**	**266**	**1455**	

A first analysis with SPAS failed to converge upon a valid maximum-likelihood Darroch estimate. The goodness-of-fit test for "complete mixing" failed, with a X^2 statistic of 121.5 on 2 degrees of freedom and p<0.01, but the test for "equal proportions" passed, with a X^2 statistic of 1.01 on 4 degrees of freedom and p=0.91. Because one test passed, the pooled Petersen estimate of 17,307 was used. The standard error of this estimate was 914 (CV=5%), and a 95% confidence interval was 15,694 – 19,411. The weir count of 17,684 fell within this confidence interval, and was very close to the pooled Petersen estimate (Table 3).

Spawning Grounds Mark-Recapture

To get an independent estimate of escapement on the spawning grounds, we planned on conducting a multiple event mark-recapture study in the inlet stream between Klag Lake and an upper lake. However, we only sampled one 2-day event. We can, however, compare this 2-day estimate with the number of sockeye salmon counted in the stream survey conducted at the same time and location of the mark-recapture study. The mark-recapture 2-day event was conducted between the pool and the second falls. A first sample of 213 sockeye salmon was caught on September 11 and marked with a left opercular punch. A second sample of 411 sockeye salmon was caught on September 12, and of these, 46 had a left opercular punch mark. Using the Chapman's modification of a Petersen estimate, we calculated the total sockeye present in this area to be 1,875 sockeye salmon with a 95% CI to be 1,500 to 2,500 fish. The stream survey count in this area was about 2,700 sockeye salmon, slightly above the upper limit of the Petersen estimate.

Approximately 40% of the sockeye escapement was in the area between Klag Lake and the upper lake in the second week of September, 6,800 sockeye spawners. We counted 2,300 sockeye salmon between Klag Lake and the first falls, 960 fish were counted in a slough above the first falls, 800 fish between the slough and the pool, and approximately 2,700 fish in the pool below the partial barrier falls (mark-recapture study area).

Adult Sockeye Salmon Population Age and Size Distribution

Similar to 2001, age 1.3 dominated the age structure, however, fewer jacks returned in 2002 compared to 2001. Age was determined for 737 sockeye salmon sampled at the weir, and the dominant class was age-1.3, representing 44% of the fish sampled. The next largest class was age-1.2, representing 28% of the fish sampled (Table 6). All sockeye salmon with only one ocean year (age-1.1 and age 2.1) were assumed to be jacks. Out of the 412 males sampled, 14 were jacks, and jacks comprised about 2% of all sockeye salmon sampled compared to 10% in 2001. The average length of sockeye salmon sampled at Klag Lake weir was 519 $\pm$ 1.8 mm (Table 7). The average length of males was 519 (SE=2.6 mm), and the average length of females was 411(SE=2.2 mm; Table 7). Altogether, fish with one freshwater year in Klag Lake comprised about 72% of the sampled escapement, about 28 % resided in freshwater for 2 years including a small number age-2.1 jacks.

Table 6. Age composition of adult sockeye salmon in the Klag Lake escapement by sex, July 4 – August 24, 2002.

Brood Year:	**1999**	**1998**	**1998**	**1997**	**1997**	**1996**	**1996**	
Age:	**1.1**	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**Total**
Male								
Sample Size	4	105	10	180	67	1	45	412
Percent	0.6	15.1	1.4	25.8	9.6	0.1	6.5	59.1
Std. Error	0.3	1.3	0.4	1.6	1.1	0.1	0.9	1.8
Female								
Sample Size		87		128	51		19	285
Percent		12.5		18.4	7.3		2.7	40.9
Std. Error		1.2		1.4	1		0.6	1.8
All Fish								
Sample Size	4	192	10	308	118	1	64	697
Percent	0.6	27.5	1.4	44.2	16.9	0.1	9.2	100
Std. Error	0.3	1.7	0.4	1.8	1.4	0.1	1.1	

Table 7. Mean fork length (mm) of adult sockeye salmon in the Klag Lake escapement by sex and age class, July 4 – August 24, 2002.

Brood Year:	**1999**	**1998**	**1997**	**1996**	**1998**	**1997**	**1996**		
Age:	**1.1**	**1.2**	**1.3**	**1.4**	**2.1**	**2.2**	**2.3**	**Not Aged**	**All Fish**
Male									
Av. Length	345	480	554	566	367	493	557	527	519
SE (av. length)	14.0	2.4	2.6		6.5	4.2	4.5	9.9	2.6
Sample Size	4	105	180	1	10	67	44	24	435
Female									
Av. Length		489	544			490	560	535	520
SE (av. length)		2.3	2.4			3.1	4.7	12.2	2.2
Sample Size		87	128			51	18	16	300
All Fish									
Av. Length	345	484	550	566	367	492	558	530	519
SE (av. length)	14.0	1.7	1.8		6.5	2.7	3.4	7.6	1.8
Sample Size	4	192	308	1	10	118	62	40	735

Subsistence Harvest Estimation

The Klag Bay subsistence fishery was open between June 1 and July 23 and closed between July 24 and August 17, due to the high catches in the subsistence fishery (~3,200 sockeye salmon) and low escapement (16 sockeye adults) through the weir. Although the ADF&G management biologist reopened the fishery on August 17 and extended to the end of the month, very few fishers returned to harvest sockeye salmon. At most, 4 subsistence boats fished on any given day and subsistence boats were seen on 16 days out of 35 fishable days, between July 1 and July 24 and again between August 17 and 27. A total of 2,371 sockeye salmon were recorded caught from 36 interviews and 8 interviews were missed (Table 8). The expanded estimate for sockeye harvest was 3,048 fish with a variance of and a range of 2,471 – 3,626 sockeye salmon (95% CI). By comparison, the ADF&G subsistence permits showed a total of 3,900 sockeye salmon were harvested by 88 permit holders.

In conjunction with the subsistence fishery, the sport fishery was also closed on the July 24, but was reopened on August 15; sport fishers participated in the fishery between July 1 and August 27. Of the 29 sport fishers observed, 27 were interviewed and 2 were missed. The expanded estimate of sport harvest was 111 sockeye salmon with a variance of 62 and a range between 96-127 sockeye salmon (95% CI; Table 8).

Participants in the two fisheries used different gear types. Sports fishers used rods and subsistence fishers used gillnets and beach seines. The technicians did not distinguish between gear types in the subsistence fishery, so an additional stratum by gear type was not analyzed. Beach seines, however, were the dominant gear used in the subsistence fishery.

The technicians reported difficulties in viewing all areas of both fisheries. In the absence of other information, we assumed that the technicians saw all boat parties. The crew did observe uncooperative parties leaving without volunteering their catch information. These were recorded as missed interviews. Inconsistent recording of time fished precluded computation of catch per unit of effort estimates. Harvest of other salmon species was negligible.

Table 8. Estimated number of salmon caught in the Klag Lake sport and subsistence fisheries during 2002.

Fishery Type	Number counted	Number sampled	Sockeye	SE	Chum	SE	Pink	SE	Coho	SE
Subsistence	36	28	3,048	294.6	59	7.7	4	1.8	15	3.2
Sport	27	25	111	5.3	3	0.1	0	0	5	1.2
Totals	63	53	3,159	294.7	62	7.7	4	1.8	20	3.5

At the time of the 2001 annual report (Conitz and Cartwright 2002), the number of sockeye salmon reported on permit returns was not available. The final number of sockeye salmon reported on permits in 2001 was 1,192 fish. The 2001 on-grounds survey estimated approximately 1,600 sockeye salmon were harvested. About 75% of the on-grounds harvest estimate was reported on subsistence permits.

Light, Temperature, and Dissolved Oxygen Profiles

Light intensity measurements were made at Station A in 2002. The shallowest euphotic zone depth (EZD) occurred in August (4.1 m) and was the deepest in October (7.8 m) with a seasonal mean of 5.8 m (Table 9). The seasonal mean is about 1 meter deeper than 2001. Unlike 2001 and other Southeast Lakes, the 1% light level was highest in the fall and lowest in the summer (August).

Table 9. The euphotic zone depth (EZD) in Klag Lake, 2002. The euphotic zone depth is the depth at which 1% of the subsurface light level attenuates in the water column. The product of the surface area and the EZD represents the area of the lake in which photosynthesis occurs.

Sample Date	EZD (m)
May 31	6.1
Jul 17	5.2
Aug 29	4.1
Oct 30	7.8
Seasonal Mean	5.8

Water temperature profiles in Klag Lake show the thermal stratification pattern typical of dimictic lakes in Southeast. The thermocline (a drop of at least 1ºC/meter) developed between 5 and 15 meters during the summer months and became isothermic by the end of October (Figure 5). The maximum epilimnetic (above the thermocline) varied only by 1 ºC throughout the season, peaking in July at 13 ºC (Figure 5). Dissolved oxygen (DO) measurements in August and October ranged between 51% saturation (October, 13 m) and 84% (August, 1m).

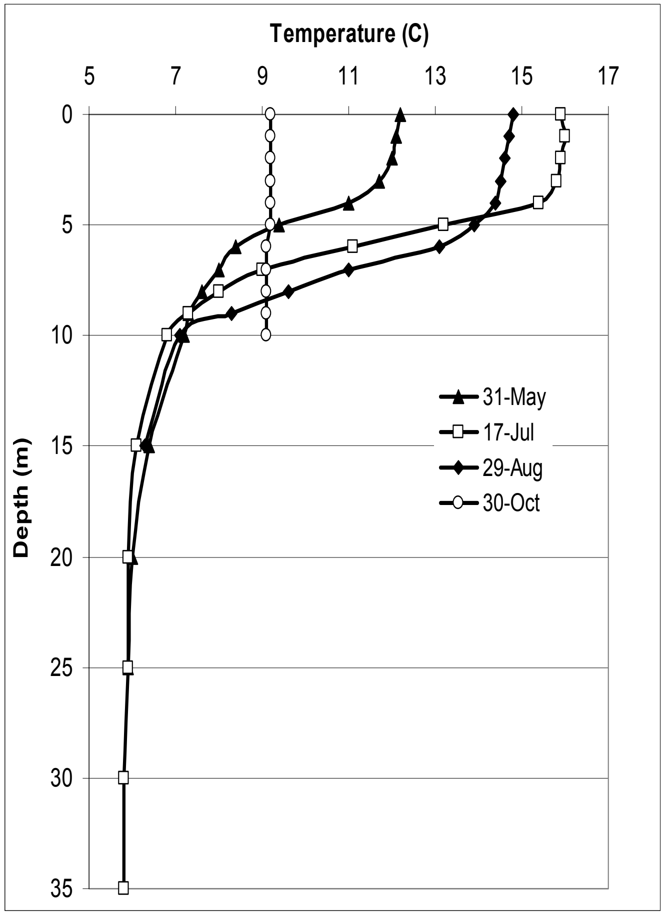

Figure 5. The 2002 temperature profiles in Klag Lake, sampled between 31 May and 30 October.

The water level in the outlet stream varied depending on the amount of precipitation. The lowest level (0.7 ft) was recorded August 6 and the highest water level (2.5 ft) occurred at week later on August 13 (Figure 4).

Secondary Production

The two plankton samples, taken on May 31 and July 17 respectively, revealed a predominance of *Cyclops* sp. and *Bosmina* sp. (Table 10). Daphnia were marginally represented, with ovigorous members of all species dominating the July 17 sample, suggesting more production occurring in the warmer months. The mean weighted biomass of all species was 249 mg/m^2 for Station A and 195 mg/m^2 for Station B. Although the size range of bosminids (0.31-0.42 mm) was below the preferred size for sockeye fry, the size range of *Daphnia l*. (0.71-1.06 mm) and the cyclopoids (0.67-1.13 mm) was well above 0.5 mm. Mean density for Station A was 140,802 no/m^2 and 138,139 no/m^2 for Station B. The zooplankton populations were dominated by the copepod *Cyclops* sp. except for the July 17 sample at Station B where the small Cladoceran *Bosmina* sp. dominated the sample (Table 10).

Table 10. 2002 Klag Lake zooplankton densities (No./m^2) by station, date, and seasonal mean.

Station A	May 31	July 17	Mean	Percent
Epischura	7,404	10,953	9,179	6.5%
Cyclops	55,765	120,479	88,122	62.6%
Ovig. Cyclops		4,840	4,840	3.4%
Bosmina	10,528	51,452	30,990	22.0%
Ovig. Bosmina	136	5,019	2,578	1.8%
Daphnia l.	68	509	289	0.2%
Ovig. Daphnia l.	0	764	382	0.3%
Holopedium	68	509	289	0.2%
Ovig. Holopedium	136		136	0.1%
Copepod nauplii	12,973		12,973	9.2%
Total				**140,802**

Station B	May 31	July 17	Mean	Percent
Epischura	21,396	8,456	14,926	11%
Cyclops	92,545	29,954	61,250	44%
Ovig. Cyclops	1,868	1,630	1,749	1%
Bosmina	9,509	76,414	42,962	31%
Ovig. Bosmina		306	306	0%
Daphnia l.	170	3,362	1,766	1%
Ovig. Daphnia l.	170	1,223	697	1%
Holopedium	679	815	747	1%
Ovig. Holopedium	340	611	476	0%
Copepod nauplii	26,830		26,830	19%
Total				**138,139**

DISCUSSION

In the second year of the Klag Lake Sockeye Salmon Stock Assessment, we successfully completed the objectives to estimate the adult sockeye escapement, describe the size and age structure of adult sockeye spawners and evaluate the productivity of Klag Lake. We were not successful in obtaining an accurate sockeye fry estimate or an independent estimate of sockeye spawners on the spawning grounds (apart from the weir mark-recapture estimate). In addition, the subsistence fishery harvest estimate may have been underestimated this year.

Although we got an approximate estimate of the number of sockeye fry in Klag Lake, we were unable to estimate the sampling error associated with this estimate. Hydroacoustic surveys will be eliminated from most of the lakes after this year because of the difficulty in obtaining an adequate sample size with the current mid-water trawl gear in these oligotrophic lakes. In addition to sample size problems, studies comparing smolt sizes and ages obtained at a weir and in the trawl samples show that this gear is biased against the larger sockeye fry in a given system (Paul Rankin and Tim Zadina personal communication). Because these problems are common to remote acoustic surveys, we consider the hydroacoustic estimates of sockeye fry a work in progress and plan on forming a working group with other sockeye biologists in Canada and Washington to discuss similar problems. We think that hydroacoustic surveys can at least measure large changes in sockeye fry populations. Improvements in the study design and trawl methods will hopefully allow us to get a more precise measurement with error bounds needed for observing smaller changes in trophic level responses.

Obtaining an independent estimate of the number of sockeye adults on the spawning grounds was not achieved this year. Once the weir was dismantled, we did not have additional crew to sample the spawning grounds throughout the fall. Given the accuracy of the weir counts (supported by the weir mark-recapture estimate), we do not think it is critical to get this independent estimate in future years. The fairly flat topography of the Klag Lake drainage, lends itself to a weir study design because the water level does not fluctuate much, even in heavy rains. Indeed, the weir count was within the 95% CI of the weir mark-recapture estimate in 2001 and 2002. One argument for obtaining an independent estimate on the spawning grounds is to develop an index of escapement in the event the weir is not funded. However, given that this is one of the largest subsistence fisheries in Southeast and is intensely fished, it is doubtful that this in-season management tool (weir) will be dropped in the near future.

This year, we attempted to mark 50% of the sockeye adults at the weir. During peak escapement times, this rate was impossible to maintain. Since it is important to mark the fish at a fairly constant rate, we will lower the marking rate to 20% in 2003. This should provide us with adequate recovery of marks on the spawning ground without compromising the precision of the escapement estimate (Jim Blick former ADF&G biometrician personal communication).

The discrepancy between the reported subsistence catch and the on-grounds harvest survey is problematic. In calculating harvest estimates from on-ground surveys, we assume that the boat-groups that were interviewed are representative of those that were not. If this assumption is violated, the creel survey harvest estimates will either overestimate or underestimate the actual catch. The technicians' written comments indicated very high catches for 2 of the non-interviewed subsistence boat parties. If this situation was true for the other 6 uncooperative subsistence boat parties, the harvest survey estimates are less than the actual harvests. Crew observations were that boat parties harvested a significant number of fish that were not reported. However, it does not make sense that they would then report their true catch or inflate their numbers on the ADF&G permit. Another possible explanation is that a boat was not even observed fishing, and so it is not counted as a missed interview but they report their catch on a permit. Efforts will be made in 2003 to improve the on-grounds estimate. Dedicating more crew time to observing the fisheries may help.

Eliminating the on-grounds survey is not recommended because the ADF&G Area Management Biologist uses in-season numbers from the Klag Lake weir to open and close the terminal fisheries throughout the season. In fact, one of the reasons that the Klag subsistence and sport fisheries were closed between July 24 and August 17 was because managers felt that not enough sockeye salmon were allowed to escape into the lake. The low water conditions exacerbated the problem and resulted in a large number of sockeye adults remaining in the estuary and being vulnerable to the terminal fishery. A comparison between the 2001 and 2002 run timing shows that the sockeye escapement was started out slow in 2002 and quickly surpassed the 2001 count when the subsistence fishery was closed and the water level rose in the outlet stream of Klag Lake the second week in August (Figure 6). When the fishery reopened August 17, relatively few fishermen returned to take advantage of the opening.

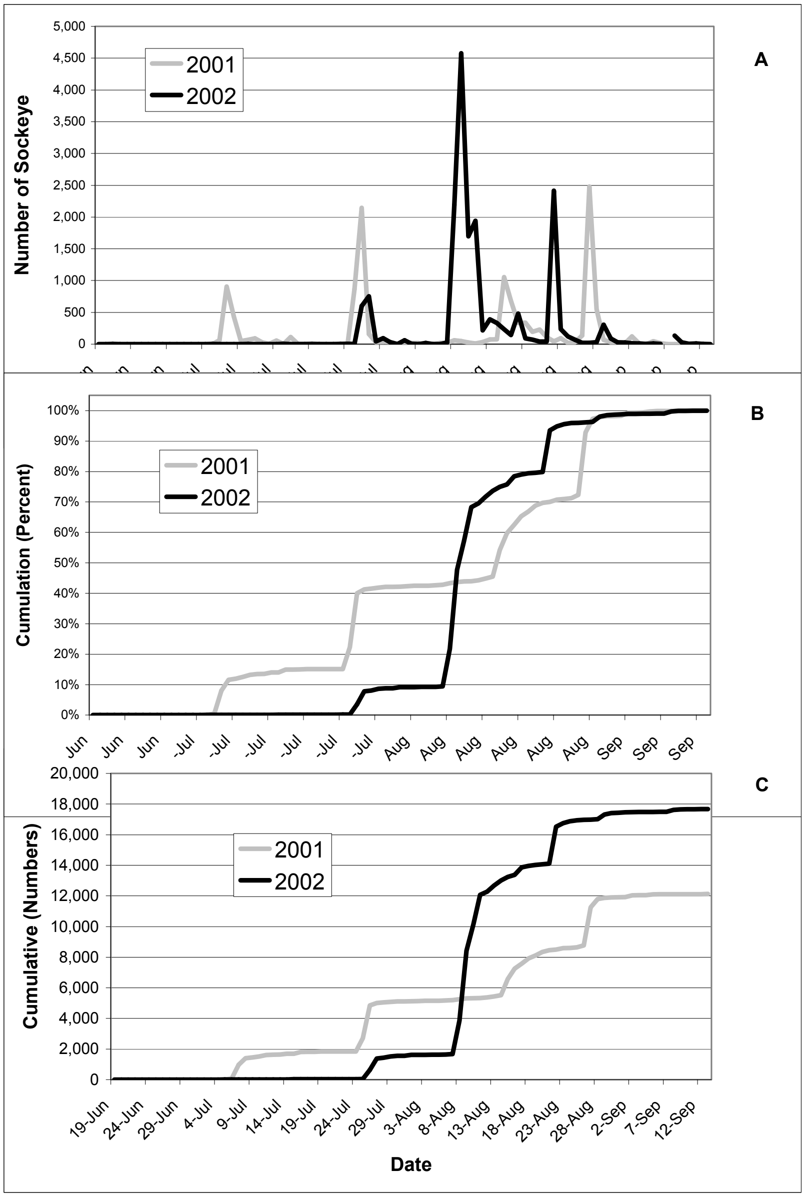

Figure 6. The daily sockeye salmon count at the weir shows that escapement peaked in August in both years (A). Although the sockeye escapement was slow to build in 2002, it quickly surpassed the 2001 escapement (B and C).

Although the weir mark-recapture study in 2001 and 2002 indicates that the weir did not leak, we think it is important to continue to conduct this component of the study as a safeguard in the event the weir is severely compromised and to document that minor leaks, should they occur. If a mark-recapture experiment is not done annually to back of the weir count, in years when the weir is obviously compromised (or not so obviously), the data and effort for that year will be worthless.

The EZD, temperature, and zooplankton densities and species composition and sockeye fry densities influence the productivity of the Klag Lake. Klag is heavily stained compared to other sockeye salmon lakes in Southeast (Conitz and Cartwright 2002) and zooplankton densities are considered average (Table 11). The mean size of *Daphnia l.* in Klag Lake was below average in 2001 but the largest in 2002 (Table 11). The presence of large numbers of stickleback (78%) in 2001 compared to 33% in 2002 suggests that the dominant small pelagic fish can vary from year to year. The percent stickleback is further reduced to 24% in 2002 if the surface tow is eliminated from the 2002 data. Furthermore, the small sample size caught in the trawl may contribute this highly variable species composition from year to year.

Table 11. Summary of the weighted mean zooplankton density (mg/m^2) for 2001 and 2002 by lake and the mean size of the *Daphnia l.*, the most preferred food of sockeye fry.

2001			2002		
Lake	Zooplankton Density (mg per m$^{2)}$	Daphnia Mean size (mm)	Lake	Zooplankton Density (mg per m$^{2)}$	Daphnia Mean size (mm)
Sitkoh	647	0.73	Sitkoh	569	0.79
Kanalku	371	0.95	Klawock	421	0.90
Salmon Bay	347	0.94	Kanalku	419	0.75
Kook	299	0.87	Kook	311	0.80
Luck	233	0.86	Luck	311	0.77
Klawock	217	none	Klag	222	0.97
Klag	175	0.65	Salmon Bay	195	0.75
Thoms	142	0.60	Thoms	119	0.57
Hetta	128	0.63	Hetta	47	0.67
Falls	105	0.66	Falls	28	0.69
Gut	33	0.60	Gut	21	0.61

Several more years of data are required to fully understand the relationships between trophic levels to determine if the sockeye production in Klag Lake is limited by escapement, spawning area or the rearing environment. Continued investigations of the strength of sockeye returns over time, the relationship between juvenile to adult production, and the response of the zooplankton populations to variable sockeye fry densities are important to understanding the dynamics of production in this lake. Funding limitations preclude us from collecting all but the data on the adult sockeye returns. Because there are no commercial fisheries in the vicinity, we can assume the sockeye returns to the terminal area represent most the recruitment by age class and brood year. Consequently, this lake system lends itself to a long-term study to develop a spawner-recruit curve to set a range of escapement that maximizes production. However, it takes 5 or 6 years of escapement data before the first few years of recruitment can be evaluated and a several more years of data to develop a spawner-recruit curve.

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APPENDICES

Appendix 1. The 2002 Klag Lake weir counts by species and sockeye salmon marking schedule. (Page 1 of 3)

			Sockeye Salmon										
Date	Water Depth (ft)	Water Temp (^oC)	Mark Used	Number Marked	Number ASL Samples	Daily Total	Cum. Total	Daily % Marked	Cum. Total Marked	Cum. % Marked	Number of Coho	Number of Pinks	Number of Chum
6/20	0.7						0		0		0		
6/21	0.72						0		0		0		
6/22	0.74						0		0		0		
6/23	0.74						0		0		0		
6/24	0.76						0		0		0		
6/25	0.85						0		0		0		
6/26	0.88						0		0		0		
6/27	0.89						0		0		0		
6/28	1.02						0		0		0		
6/29	0.97						0		0		0		
6/30	0.92						0		0		0		
7/1	0.85						0		0		0		
7/2	0.82						0		0		0		
7/3	0.86						0		0		0		
7/4	1.15		AD+LA	3	3	3	3	100%	3	100%	0		
7/5	1.2		AD+LA	0	0	0	3		3	100%	0		
7/6	1.19		AD+LA	0	0	0	3		3	100%	0		0
7/7	1.1		AD+LA	0	0	0	3		3	100%	0		0
7/8	1		AD+LA	0	1	1	4	0%	3	75%	0		0
7/9	0.93		AD+LA	0	0	0	4		3	75%	0		0
7/10	0.88		AD+LA	2	2	4	8	50%	5	63%	1		0
7/11	0.9		AD+LA	0	0	1	9	0%	5	56%	0		0
7/12	1		AD+LA	0	0	0	9		5	56%	0		0
7/13	0.95		AD+LA	0	0	0	9		5	56%	0		0
7/14	1		AD+LA	5	5	5	14	100%	10	71%	0		0
7/15	1		AD+LA	1	1	1	15	100%	11	73%	1		0
7/16	1		AD+LA	0	0	0	16	0%	11	69%	0		0
7/17	0.95			0	0	0	15		11	73%	0		0

- continued -

AD+LA

Appendix 1. (Page 2 of 3)

Date	Water Depth (ft)	Water Temp (^{o}C)	Mark Used	Number Marked	Number ASL Samples	Daily Total	Cum. Total	Daily % Marked	Cum. Total Marked	Cum. % Marked	Number of Coho	Number of Pinks	Number of Chum
7/18	1			0	0	0	15		11	73%	0		0
7/19	1			0	0	0	15		11	73%	0		0
7/20	0.94			0	0	0	15		11	73%	0		0
7/21	0.89	AD+LA		0	0	1	16		11	69%	0		0
7/22	1	AD+LA	AD+LA	0	0	2	18	0%	11	61%	0		0
7/23	1.1	AD+LA	AD+LA	1	1	7	25	14%	12	48%	1		0
7/24	1.13	AD+LA	AD+LA	4	4	4	29	100%	16	55%	112		0
7/25	1.42		AD+LA	147	147	598	627	25%	163	26%	68		0
7/26	1.35		AD+LA	162	162	751	1378	22%	325	24%	33		0
7/27	2.3	15	AD+LP	10	10	44	1422	23%	335	24%	0		0
7/28	2	15	AD+LP	20	20	95	1517	21%	355	23%	5		0
7/29	1.4	15	AD+LP	15	15	29	1546	52%	370	24%	0		0
7/30	1.05	15	AD+LP	0	0	0	1546		370	24%	0		0
7/31	0.98	17	AD+LP	20	20	61	1607	33%	390	24%	0		0
8/1	0.96	15	AD+LP	0	0	5	1612	0%	390	24%	0		0
8/2	0.86	16.5	AD+LP	0	0	1	1613	0%	390	24%	1		0
8/3	0.81	18	AD+LP	0	0	18	1631	0%	390	24%	0		0
8/4	0.77	17	AD+LP	0	0	0	1631		390	24%	0		0
8/5	0.74	18	AD+LP	0	0	1	1632	0%	390	24%	0		0
8/6	0.71	17	AD+LP	7	7	25	1657	28%	397	24%	0	1	0
8/7	0.75	16	AD+LP	120	120	2192	3849	5%	517	13%	543	53	0
8/8	2.4	16	AD+LP	437	80	4577	8426	10%	954	11%	143	411	0
8/9	2	15.5	AD+LP	279	20	1699	10125	16%	1233	12%	267	625	1
8/10	1.68	15	AD+LP	109	0	1941	12066	6%	1342	11%	269	905	1
8/11	1.42	16	AD+LP	161	40	215	12281	75%	1503	12%	70	50	0
8/12	1.82	15	AD+LP	354	40	389	12670	91%	1857	15%	145	350	0
8/13	2.45		AD+LP	303	0	333	13003	91%	2160	17%	82	486	1
8/14	1.78	15	AD+LP	182	0	235	13238	77%	2342	18%	133	224	1
8/15	1.5	15	AD+D	95	0	142	13380	67%	2437	18%	47	180	1
8/16	1.2	15	AD+D	140	0	482	13862	29%	2577	19%	115	1403	0

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Appendix 1. (Page 3 of 3)

Date	Water Depth (ft)	Water Temp (^oC)	Mark Used	Number Marked	Number ASL Samples	Daily Total	Cum. Total	Daily % Marked	Cum. Total Marked	Cum. % Marked	Number of Coho	Number of Pinks	Number of Chum
8/17	1.08	14	AD+D	33	10	92	13954	36%	2610	19%	24	197	0
8/18	1	15	AD+D	0	0	69	14023	0%	2610	19%	17	91	0
8/19	0.98	14.72	AD+D	26	10	39	14062	67%	2636	19%	4	17	0
8/20	0.97	14.8	AD+D	31	10	40	14102	78%	2667	19%	10	15	0
8/21	1.9	14	AD+D	197	10	2413	16515	8%	2864	17%	500	8358	2
8/22	2	14	AD+D	77	0	236	16751	33%	2941	18%	112	1650	5
8/23	1.85	14	AD+D	32	0	122	16873	26%	2973	18%	115	409	2
8/24	1.6	14	AD+D	35	0	66	16939	53%	3008	18%	58	564	0
8/25	1.4	14	AD+D	15	0	22	16961	68%	3023	18%	33	119	0
8/26	1.3	15	AD+D	16	0	20	16981	80%	3039	18%	17	54	0
8/27	1.35	14	AD+D	4	0	31	17012	13%	3043	18%	29	268	5
8/28	1.55	14	AD+D	65	0	303	17315	21%	3108	18%	221	3272	0
8/29	1.7	14	AD+D	30	0	87	17402	34%	3138	18%	71	1107	4
8/30	1.7	14	AD+D	11	0	28	17430	39%	3149	18%	43	320	4
8/31	1.6	15	AD+D	17	0	24	17454	71%	3166	18%	16	103	0
9/1	1.5	15	AD+D	0	0	21	17475	0%	3166	18%	32	116	1
9/2	1.35	15	AD+D	0	0	10	17485	0%	3166	18%	10	68	0
9/3	1.35	15	AD+D	0	0	2	17487	0%	3166	18%	0	46	0
9/4	1.75	15	AD+D	0	0	8	17495	0%	3166	18%	8	6	0
9/5	1.75	14	AD+D	0	0	2	17497	0%	3166	18%	2	12	0
9/6	1.05	15	AD+D	0	0	0	17497		3166	18%	1	18	0
9/7	1.35	14	AD+D	0	0	133	17630	0%	3166	18%	314	5423	0
9/8	1.6	14	AD+D	7	0	27	17657	26%	3173	18%	39	330	0
9/9	1.67	13	AD+D	0	0	5	17662	0%	3173	18%	19	52	0
9/10	1.3	13.5	AD+D	0	0	8	17670	0%	3173	18%	14	57	0
9/11	1.5	13	AD+D	0	0	4	17674	0%	3173	18%	3	24	0
9/12			AD+D	0		10	17684		3173	18%			

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